Detection and Classification of Tomato Plant Leaf Diseases Using Convolutional Neural Network

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Abstract --- *India's economy is largely dependent upon agricultural production. Agriculture plays a huge role on India's GDP. Due to which the detection of diseases in plant leaves becomes very crucial. The manual detection of these diseases is very complex and becomes in-feasible. Hence, the solution to this problem is using machine learning approaches. This work presents a framework based on the Convolutional Neural Network (CNN) model for the identification and classification of tomato leaf diseases.*

Keywords: Leaf Disease, Machine Learning, Image Processing, Convolution Neural Network (CNN), Classification

I. INTRODUCTION

Crop infections are essential considerations because they impact both humans and animals alike. It can cause significant reduction in the variety and quality of agricultural crops. Disease identification and diagnosis is an essential and crucial task. Several researchers have employed image processing techniques to rapidly and reliably identify and monitor plant diseases after early disease detection. When such diseases are not apparent to the naked eye but actually exist, it is hard to detect them with a naked eye. So it would be too late to assess so take precautionary steps for the disease before it is noticeable. Early phase detection and recognition of diseases in plants is very beneficial in presenting early signs of disease identification. Early detection of the disease is very useful for small-scale land farmers and is able to monitor the insects through organic pesticides by use limited amounts of chemical pesticides. The regular monitoring and early identification of disease is not possible for large land farmers and results in a serious disease epidemic and growth of pests that cannot be managed by organic means. Farmers in this situation are forced to use toxic chemicals to kill the disease to maintain crop yield. This problem can be solved using advanced image processing techniques and machine learning to automate the farm monitoring process. The proposed research aims to make the automated system simple for the farmer to use the tool to detect diseases in plants early. The result will be shown on the user interface after evaluating the diseases. With the help of images the diseases can be detected. The processing which these components integrate is divided into two main parts. The features are taken with as input to the classifier, the product either of a regular leaf or diseased images. Then the classifier discovers the relationship between the extracted features and the potential outcomes of the disease on the leaf.

II. CONVOLUTIONAL NEURAL NETWORK

Deep learning falls under the category of sequential-layered machine learning techniques [2]. The result of prior level would be the entry to the current level. The learning process is of three types they are unsupervised, supervised or semi-supervised. The most efficient way of representing the data is to use a highly optimized interpretation predictive algorithm. The features are extracted automatically while training the model thus Deep learning need not divide the features or classify them. It is also used in many fields of research including image analysis, image reconstruction, voice recognition, analysis of natural languages and bioinformatics [2].

In this study, CCN is the deep learning method used. CNN, which can immediately recognize & identify objects within minimal processing, is useful for digital photo processing so CNN is chosen in the work. CNN can efficiently distinguish the necessary functionality with its muti-layered model for the application [1]. CNN's 4 primary layers are convolution layer, layer of pooling, layer of activation feature and fully linked level shown in figure 1.

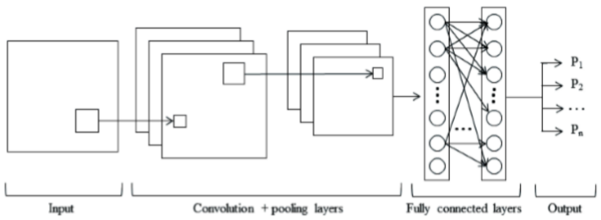

Fig.1: General CNN Architecture [1]

A. Convolutional Layer

In CNN 'C' Stands for convolution as it's the important layer. Throughout this layer, a sequence of mathematical computations extracts the feature map of the origin image. To minimize the size of the source image a buffer has been used [5]. In each step the output is summarized by multiplying the variables in the image by the filter values. Figure 2 demonstrates the convolution process for the 5&5 source image and a 3&3 buffer in the convolution layer [3].

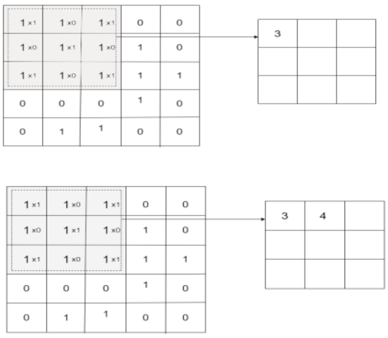

Fig 2:Convolution operation for 5x5 input image and 3x3 filter [8]

B. Pooling Layer

Throughout this layer an output matrix produced from the layer of convolution its size is decreased. This layer typically uses 2x2 size filters, while filters of various sizes may be used [4]. In this layer functions such as max pooling, average pooling, and L2-norm pooling are used. In this analysis, Max pooling filter with stride 2 was added. By converting the largest value in the sub windows, a new matrix is generated, this is called max pooling.

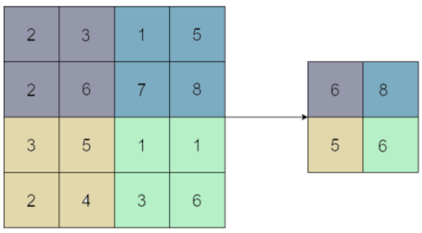

Fig 3: Max pooling with 2x2 filters [1]

C. Activation Layer

The activation function in duplicate networks provides a connection in both the input and output layers. It does affect the efficiency of the network. This activation function can be used for nonlinear network training. There are several activation modes, like linear, sigmoid, hyperbolic tangent, however the activation layer in CNN utilizes the nonlinear function ReLU (Rectified Linear Unit) [10]. The variables below zero are modified to 0, while variables above 0 are changed by (1) in ReLU as indicated in equation (1)

f(x) = 0, if x<0.
x, if else. Eq (1)

D. Fully Connected (FC) Layer

The input for the FC Layer (in figure 3) will be the last matrix to be determined, until the operations of convolution, pooling and activation have been completed. In this layer identification and classification.

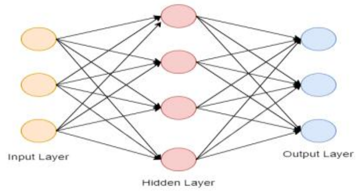

Fig 3: Fully Connected Layer

III. RESULTS AND ACCURACY

The developed system is tested on a sample size of nearly 2511 Tomato Leaf Images. 75% of the dataset is used for training and 25% is used for testing. Analysis of the experimental results is done by generating a confusion matrix. A confusion matrix is a chart which is used to define a classification model's output on a series of test data in which the real variables are specified. Each prediction falls into one of these four categories [5].

(i)True Negative (TN): Predicts data that is classified false as false.
(ii) True Positive (TP): Predicts data which is classified true as true.
(iii) False Positive (FP): Also known as "false alarm," this is a Form 1 error where the test tests a single condition and erroneously predicts a positive one.
(iv) False Negative (FN): This is a Form 2 error in which a single condition is verified and a true instance is predicted as negative by the classifier.

Figure 4 represents the Confusion Matrix that is obtained for the developed system. Using this confusion matrix, varying performance metrics are used to analyze the current model developed for detection and identification of Tomato leaf diseases. Here, the accuracy as indicated in Eq (2) of the model for current work is computed as the correct number of predictions made with respect to total number of data samples.

Accuracy=TP+TN/TP+FP+TN+FN Eq (2)

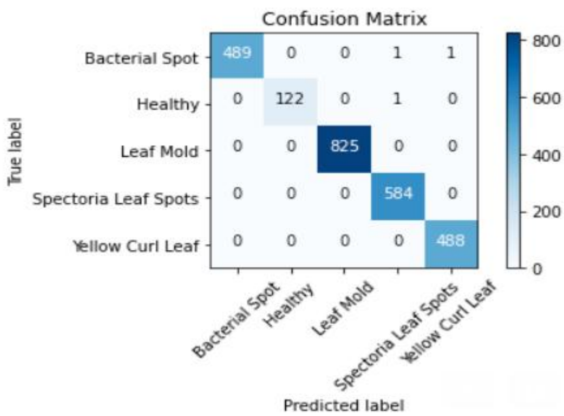

Fig 4: Confusion Matrix

By computing with the help of the formula in Eq (2) we are getting an accuracy of around 95%.

IV. CONCLUDING REMARKS

A method for detecting and classifying tomato-leaf infections is described in this study focused on the Convolutional Neural Network approach. Each matrix of the source image was convoluted. ReLU activation function and max pooling is used throughout the exit level. Complete feature vectors used to train & check procedures throughout the system which were generated through original images [6]. To conduct classification, the tests were performed on healthy and diseased images of the crop. It is found that four various types of tomato leaf diseases are successfully recognized in the developed process. Further the work can be extended to analyze the model with varying performance evaluation metrics. Also, a recommendation system for farmers can be developed to aid in the agricultural field.

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